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Chapter 57: Nutrition Assessment and Support

INTRODUCTION

- Malnutrition encompasses both undernutrition and overnutrition (obesity) and is a consequence of nutrient imbalance. Starvation-associated malnutrition, marasmus, results from prolonged inadequate intake, absorption, or utilization of protein and energy. Severe acute disease or injury (major infections, burns, trauma) or chronic inflammatory diseases (Crohn's disease), organ failure, or cancer can cause disease-related malnutrition through increased metabolic demands. Both undernutrition and overnutrition alter subcellular, cellular, or organ function that increases morbidity and mortality.
- For information on overnutrition or obesity, see Chapter 56.
- Nutrition screening is a systematic method to identify individuals with preexisting malnutrition or those at risk for malnutrition for whom a detailed nutrition assessment is warranted.
- Nutrition assessment integrates a comprehensive medical, surgical, and dietary history with a nutrition-focused physical exam (NFPE), including anthropometrics and laboratory measurements. The NFPE uses a system-based approach to assess for abnormal nutrition-related clinical and physical findings in the body.
- Goals of nutrition assessment include identification of risk factors associated with malnutrition and the development of undernutrition and complications, estimation of nutrition needs, and establishment of baseline parameters to measure therapy outcomes.

NUTRITION ASSESSMENT

ANTHROPOMETRIC MEASUREMENTS

- Anthropometric measurements assess body size, weight, and proportions to compare individuals with population standards. Common measurements include weight, stature, head circumference (in children under 3), and waist circumference. Limb measurements (eg, skinfold thickness [to estimate subcutaneous fat], mid-arm muscle circumference [to estimate skeletal muscle mass], and wrist circumference [to estimate abdominal {visceral} fat content]) and bioelectrical impedance analysis (BIA) may be useful in selected individuals.
- Interpretation of actual body weight (ABW) includes consideration of ideal body weight for height, usual body weight (UBW), fluid status, and age. Calculate change over time as the percentage of UBW. Unintentional weight loss, especially rapid weight loss (5% of UBW in 1 month or 10% of UBW in 6 months), increases the risk of nutrition-related poor clinical outcomes in adults.
- Appropriate growth is the best indicator of adequate nutrition in children. Plot weight, stature, head circumference (until 3 years), and body mass index (BMI) (after 2 years) on the appropriate growth curve.
- BMI is another index of weight-for-height. Interpretation of BMI should include consideration of sex, frame size, race/ethnicity, and age. BMI values greater than 25 kg/m^2 are indicative of overweight, and values less than 18.5 kg/m^2 are indicative of undernutrition. BMI is calculated as follows:

$$\text{Body weight (kg)}/[\text{height (m)}]^2 \textbf{ or } [\text{Body weight (lb)} \times 703]/[\text{height (in)}]^2$$

- BIA is a simple, noninvasive, and relatively inexpensive method to assess lean body mass and total body water and its distribution. It relies on differences in conductivity between fat and lean tissue. Hydration status should be considered in interpreting results. Current guidelines do not provide recommendations for BIA use in clinical practice.

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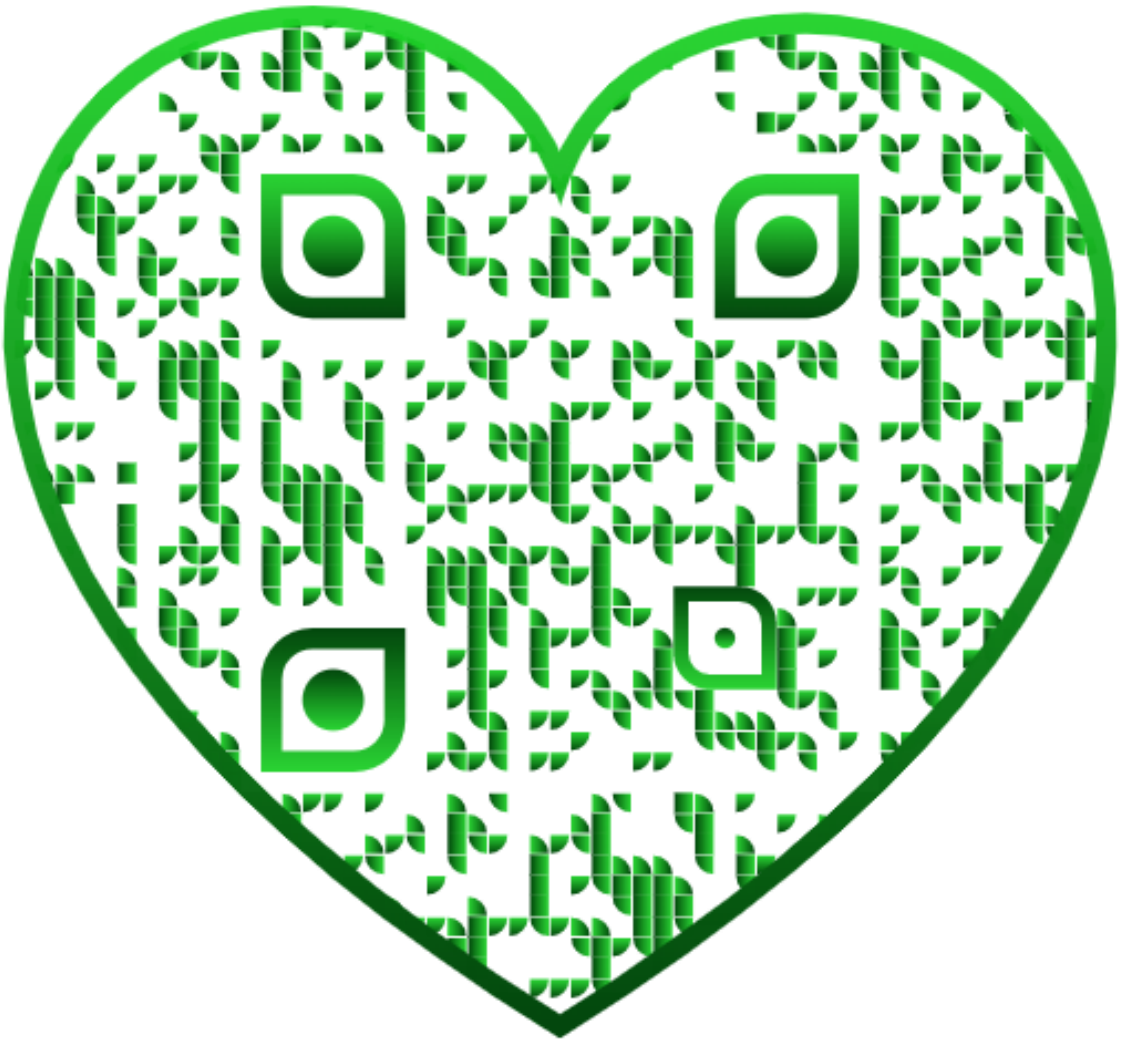

BIOCHEMICAL AND IMMUNE FUNCTION STUDIES

- Interpret visceral protein concentrations (**Table 57-1**) relative to the individual's overall clinical condition and inflammatory state. Factors other than nutrition can affect the serum protein concentrations, including age; abnormal kidney (nephrotic syndrome), gastrointestinal (GI) tract (protein-losing enteropathy), or skin (burns) losses; hydration (dehydration results in hemoconcentration, overhydration in hemodilution); liver function (synthesis); and metabolic stress and inflammation (chronic disease, sepsis, trauma, surgery, infection).
- Nutrition status affects immune function directly or indirectly. Total lymphocyte count and delayed cutaneous hypersensitivity reactions can aid nutrition assessment, but a lack of specificity limits their usefulness as nutrition status markers.

  ✓ Delayed cutaneous hypersensitivity is commonly assessed using antigens to which the patient was likely previously sensitized, such as mumps and *Candida albicans*. Anergy is associated with severe malnutrition; immune response can be restored with nutrition repletion.

TABLE 57-1

Assessment of Serum Visceral Proteins

Serum Protein	Half-Life (Days)	Function	Factors Resulting in Increased Values	Factors Resulting in Decreased Values
Albumin	18–20	Maintains plasma oncotic pressure; transports small molecules	Dehydration, anabolic steroids, insulin, infection	Fluid overload; edema; kidney dysfunction; nephrotic syndrome; poor dietary intake; impaired digestion; burns; heart failure; cirrhosis; thyroid, adrenal, or pituitary hormones; trauma; sepsis
Transferrin	8–9	Binds Fe in plasma; transports Fe to bone	Fe deficiency, pregnancy, hypoxia, chronic blood loss, estrogens	Chronic infection, cirrhosis, burns, enteropathies, nephrotic syndrome, cortisone, testosterone
Prealbumin (transthyretin)	2–3	Binds T_3 and, to a lesser extent, T_4; retinol-binding protein carrier	Impaired kidney function	Cirrhosis, hepatitis, stress, surgery, inflammation, hyperthyroidism, cystic fibrosis, burns, zinc deficiency

Fe, iron; T_3, triiodothyronine; T_4, thyroxine.

SPECIFIC NUTRIENT DEFICIENCIES

- Biochemical assessment of trace element, vitamin, and essential fatty acid deficiencies is based on serum concentrations.
- Clinical syndromes are associated with deficiencies of the following trace elements: chromium, copper, iodine, iron, manganese, molybdenum, selenium, and zinc.
- Single vitamin deficiencies are uncommon; multiple vitamin deficiencies more commonly occur with malnutrition. For information on iron deficiency and other anemias, see Chapter 30.
- Essential fatty acid deficiency is rare but can occur with prolonged lipid-free parenteral nutrition (PN), very low-fat enteral formulations or diets, high medium-chain triglyceride–containing diets, severe fat malabsorption, or severe malnutrition. The body can synthesize all fatty acids except

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for linoleic and α-linolenic acid.

- Carnitine can be synthesized from lysine and methionine, but hepatic synthesis is decreased in premature infants. Low carnitine levels can occur in premature infants receiving PN or carnitine-free diets.

ASSESSMENT OF NUTRIENT REQUIREMENTS

- Assess nutrient requirements in the context of patient-specific factors (eg, age, sex, size, clinical condition, nutrition status, and physical activity).
- Healthy adults should consume 45%–65% of total calories from carbohydrates, 20%–35% from fat, and 10%–35% from protein. Recommendations are similar for children, except that infants should consume 40%–50% of total calories from fat.

Energy Requirements

- The simplest method to determine energy requirements is to use population estimates of calories required per kilogram of body weight.
- Healthy adults with normal nutrition and minimal illness require about 20–25 kcal ABW/kg/day (84–105 kJ ABW/kg/day). Children require approximately 130%–150% of basal metabolic rate plus extra calories to support activity and growth. Consult references for equations to estimate energy expenditure in adults and children.
- Energy requirements for all ages increase with fever, sepsis, major surgery, trauma, burns, long-term growth failure, and with chronic conditions (eg, bronchopulmonary dysplasia, congenital heart disease, and cystic fibrosis).

Protein, Fluid, and Micronutrient Requirements

Protein

- Protein requirements are based on age, sex, nutrition status, disease state, and clinical condition. The usual recommended daily protein allowances are 0.8 g/kg for adults, 1.5 g/kg for adults over 60 years of age, 1.5–2 g/kg for patients with metabolic stress (eg, infection, trauma, surgery), and 2.5–3 g/kg for patients with burns.

Fluid

- Daily adult fluid requirements are approximately 30–40 mL/kg.
- Fluid requirements for children and preterm infants who weigh less than 10 kg are at least 100 mL/kg/day. An additional 50 mL/kg should be provided for each kilogram of body weight between 11 and 20 kg, and 20 mL/kg for each kilogram greater than 20 kg.
- Factors increasing fluid requirements include but are not limited to GI losses, fever, sweating, and increased metabolism. Kidney or heart failure and hypoalbuminemia with starvation may decrease fluid requirements.
- Assess fluid status by monitoring urine output and specific gravity, serum electrolytes, and weight changes. An hourly urine output of at least 1 mL/kg for children and 40–50 mL for adults is needed to ensure tissue perfusion.

Micronutrients

- Requirements for micronutrients (ie, electrolytes, minerals, trace elements, and vitamins) vary with age, sex, route of ingestion, and underlying clinical conditions.
- Sodium, potassium, magnesium, and phosphorus requirements are typically decreased in patients with kidney failure, whereas calcium requirements are increased (see Chapters 73 and 74).

Drug–Nutrient Interactions

- Concomitant drug therapy can alter serum concentrations of vitamins (**Table 57-2**), minerals, and electrolytes.

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- Some drug delivery vehicles contain nutrients. For example, the vehicle for propofol is 10% lipid emulsion, and most intravenous (IV) therapies include dextrose or sodium.

TABLE 57-2

Drug and Nutrient Interactions

Drug	Effect
Angiotensin-converting enzyme inhibitors	Increased urinary zinc losses
Angiotensin receptor blockers	Increased urinary zinc losses
Antacids	Thiamine deficiency
Antibiotics	Vitamin K deficiency
Aspirin	Folic acid deficiency; increased vitamin C excretion
Cathartics	Increased requirements for vitamins D, C, and B_6
Cholestyramine	Vitamins A, D, E, and K and β-carotene malabsorption
Colestipol	Vitamins A, D, E, and K and β-carotene malabsorption
Corticosteroids	Decreased vitamins A, D, and C
Diuretics (loop)	Thiamine deficiency
Diuretics (thiazides)	Increased urinary zinc losses
Efavirenz	Vitamin D deficiency caused by increased metabolism of 25(OH)D and $1,25(OH)_2D$
$Histamine_2$ antagonists	Vitamin B_{12} malabsorption (reduced acid results in an impaired release of B_{12} from food)
Isoniazid	Vitamin B_6 and niacin deficiency
Isotretinoin	Vitamin A increases toxicity
Mercaptopurine	Niacin deficiency
Methotrexate	Folic acid inhibits effect
Orlistat	Vitamins A, D, E, and K malabsorption caused by fat malabsorption
Pentamidine	Folic acid deficiency
Phenobarbital	Increased vitamin D metabolism
Phenytoin	Increased vitamin D metabolism; decreased folic acid concentrations

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Primidone	Folic acid deficiency
Protease inhibitors	Vitamin D deficiency (impaired renal hydroxylation)
Proton pump inhibitors	Decreased iron and vitamin B_{12} absorption (reduced acid results in an impaired release of B_{12} from food)
Sulfasalazine	Folic acid malabsorption
Trimethoprim	Folic acid depletion
Warfarin	Vitamin K inhibits effect; vitamins A, C, and E may affect prothrombin time
Valproic acid	Zinc, carnitine
Zidovudine	Folic acid and B_{12} deficiencies increase myelosuppression

NUTRITION SUPPORT

- The primary objective of nutrition support therapy is to promote positive clinical outcomes of an illness and improve quality of life.

ENTERAL NUTRITION

- Enteral nutrition (EN) delivers nutrients by tube or mouth into the GI tract; we will focus on delivery through an enteral access device (eg, feeding tube). The goal of EN is to provide calories, macronutrients, and micronutrients to those who are unable to achieve these requirements from an oral diet and have a functioning GI tract and method of enteral access. Potential indications include neoplastic disease, organ dysfunction, hypermetabolic states, GI disease, and neurologic impairment.
- Distal mechanical intestinal obstruction, bowel ischemia, and necrotizing enterocolitis are contraindications to EN. Contraindications to tube placement include active peritonitis and uncorrectable coagulopathy. Conditions that challenge the success of EN include severe diarrhea, protracted vomiting, enteric fistulas, severe GI hemorrhage, hemodynamic instability, and intestinal dysmotility.
- EN or PN are recommended to provide nutrition to critically ill patients during the first week of intensive care unit admission. Advantages of EN over PN include maintaining GI tract structure and function; fewer metabolic, infectious, and technical complications; and lower costs.
- The timing of initiation of EN in critically ill patients is of clinical significance. Initiation within 24–48 hours of admission to an intensive care unit is associated with decreased disease severity and infectious complications when compared with the initiation of feedings after 48 hours. If patients are only mildly to moderately stressed and well nourished, EN initiation can be delayed until oral intake is inadequate for 5–7 days.

Access

- EN can be administered through four routes, which have different indications, tube placement options, advantages, and disadvantages (**Table 57-3**). The choice depends on the anticipated duration of use and the feeding site (ie, stomach vs small bowel).
- The stomach is generally the least expensive and least labor-intensive access site; however, patients who have impaired gastric emptying are at risk for aspiration and pneumonia.
- Long-term access with gastrostomy and jejunostomy tubes should be considered when EN is anticipated for more than 4–6 weeks.

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TABLE 57-3

Options and Considerations in the Selection of an EAD

EAD	EN Duration/Patient Characteristics	EAD Placement Options	Advantages	Disadvantages
Nasogastric or orogastric	Short term Intact gag reflex Normal gastric emptying	Manually at bedside	Ease of placement Allows for all methods of administration Inexpensive Multiple commercially available tubes and sizes	Potential tube displacement Potential increased aspiration risk
Nasojejunal	Short term Impaired gastric motility or emptying High risk of GER or aspiration	Manually at bedside Fluoroscopically Endoscopically	Potential reduced aspiration risk Allows for early postinjury or postoperative feeding Multiple commercially available tubes and sizes	Manual transpyloric passage requires greater skill Potential tube displacement or clogging Bolus or intermittent feeding not tolerated
Gastrostomy	Long term Normal gastric emptying	Surgically Endoscopically Radiologically Laparoscopically	Allows for all methods of administration Low-profile buttons available Large-bore tubes less likely to clog Multiple commercially available tubes and sizes	Attendant risks associated with each type of procedure Potential increased aspiration risk Risk of stoma site complications
Jejunostomy	Long term Impaired gastric motility or gastric emptying High risk of GER or aspiration	Surgically Endoscopically Radiologically Laparoscopically	Allows for early postinjury or postoperative feeding Potential reduced aspiration risk Multiple commercially available tubes and sizes Low-profile buttons available	Attendant risks associated with each type of procedure Bolus or intermittent feeding not tolerated Risk of stoma site complications

EAD, enteral access device; EN, enteral nutrition; GER, gastroesophageal reflux.

Administration Methods

- Administer EN by continuous, cyclic, bolus, intermittent, or volume-based methods. The choice depends on the location of the feeding tube tip, patient's clinical condition, intestinal function, and tolerance to EN regimen.
- Continuous EN is preferred for initiating therapy and is well tolerated. Disadvantages include cost and inconvenience associated with pump and administration sets.
- Cyclic EN has the advantage of allowing breaks from the infusion system, thereby increasing mobility, especially if EN is administered nocturnally.
- Bolus EN is most commonly used in patients in the home or long-term care setting who have a gastrostomy. Advantages include short administration time (eg, 5–10 minutes) and minimal equipment (eg, a syringe). Bolus EN has the potential disadvantages of causing cramping, nausea, vomiting, aspiration, and diarrhea.

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- Intermittent EN is similar to bolus EN except it is administered over 20–60 minutes, improving tolerability but requiring more equipment (eg, reservoir bag and infusion pump). Like bolus EN, intermittent EN mimics normal eating patterns.
- Protocols outlining initiation and advancement criteria optimize achievement of nutrient goals based on GI tolerance.

Formulations

- Historically, EN formulations were designed to provide essential nutrients, including macronutrients (eg, carbohydrates, fats, and proteins) and micronutrients (eg, electrolytes, trace elements, vitamins, and water).
- Over time, formulations have been enhanced to improve tolerance and meet specific patient needs. For example, immunonutrients or pharmaconutrients are added to modify the disease process or improve clinical outcome; however, these health claims are not regulated by the FDA.
- The molecular form of the protein source determines the amount of digestion required for absorption within the small bowel. The carbohydrate component usually provides the major source of calories; polymeric entities are preferred over elemental sugars. Vegetable oils rich in polyunsaturated fatty acids are the most common sources of fat in EN formulations.
- Soluble and insoluble fiber may be added. Potential benefits of soluble fiber include trophic effects on colonic mucosa, promotion of sodium and water absorption, and regulation of bowel function.
- Osmolality is a function of the size and quantity of ionic and molecular particles primarily related to protein, carbohydrate, electrolyte, and mineral content. The osmolality of EN formulations for adults ranges from 280 to 875 mOsm/kg (mmol/kg). Osmolality is commonly thought to affect GI tolerability, but there is a lack of supporting evidence.

Classification of Enteral Feeding Formulations

- EN formulations are classified by their composition and intended patient population (**Table 57-4**). The development of an evidence-based, enteral formulary should focus on clinically significant characteristics of available formulations and avoid duplication.

TABLE 57-4

Adult Enteral Nutrition Formulation Classification System

Category	Features	Indications
Standard polymeric	• Isotonic • 1–1.2 kcal/mL (4.2–5 kJ/mL) • NPC:N 125:1–150:1 • May contain fiber	• Designed to meet the needs of the majority of patients • Functioning GI tract • Not suitable for oral use
High protein	• NPC:N <125:1 • May contain fiber	• Protein requirements >1.5 g/kg/day, such as trauma patients and those with burns, pressure sores, or wounds • Hypocaloric, high-protein regimens due to obesity • Concurrent use of nonnutritive sources (eg, propofol, clevidipine, dextrose-containing IV fluids)
High caloric density	• 1.5–2 kcal/mL (6.3–8.4 kJ/mL) • Lower electrolyte content per calorie • Hypertonic	• Fluid and/or electrolyte restriction, such as kidney dysfunction (acute or chronic)

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Elemental	• High proportion of free amino acids • Low in fat	• Low fat (eg, chyle leaks) • Use has generally been replaced by peptide-based formulations
Peptide-based	• Contains dipeptides and tripeptides • Contains MCTs	• Indications/benefits not clearly established • Trial may be warranted with intolerance to intact protein due to malabsorption
Blenderized (food-based)	• 1.5 kcal/mL (6.3 kJ/mL) • Contain pureed foods and/or liquids • Commercially available products with features similar to other EN products (ie, polymeric, hydrolyzed protein, plant-based, low carbohydrate) • Formulations may also be prepared in the home setting using a blender	• Largely based on patient preferences; reasons may be medical (eg, allergies or GI tolerance) or personal (eg, religious, cultural, ethical) in nature
Disease-Specific		
Kidney	• Calorically dense • Protein content varies • Low electrolyte content	• Alternative to high caloric density formulations, but generally more expensive
Lung	• High fat, low carbohydrate • Contains MCTs and antioxidants	• Pulmonary diseases (eg, cystic fibrosis, COPD)
Diabetes	High fat, low carbohydrate	• Alternative to standard, fiber-containing formulation with uncontrolled hyperglycemia
Immune-modulating	Supplemented with glutamine, arginine, nucleotides, and/or omega-3 fatty acids	• Major elective GI surgery, trauma, burns, head and neck cancer, and use of mechanical ventilation • Use with caution with sepsis • Select nutrients may be beneficial or harmful in subgroups of critically ill patients
Oral nutrition supplements	• Sweetened for taste • Hypertonic	• Supplementation to an oral diet

COPD, chronic obstructive pulmonary disease; GI, gastrointestinal; IV, intravenous; MCT, medium-chain triglyceride; NPC:N, nonprotein calorie-to-nitrogen ratio.

Complications and Monitoring

- Monitor patients for metabolic, GI, and mechanical complications of EN (**Table 57-5**).
- Metabolic complications associated with EN are similar to those of PN, but the incidence is lower.

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- GI complications include nausea, vomiting, abdominal distention, cramping, aspiration, diarrhea, and constipation. Diarrhea may be caused by a number of factors, and management should be directed at identifying and correcting the most likely cause(s).
- Mechanical complications include tube occlusion or malposition and inadvertent nasopulmonary intubation. Techniques for clearing occluded tubes include pancreatic enzymes in sodium bicarbonate and using a declogging device. Techniques for maintaining patency include flushing with at least 15–30 mL of water before and after medication administration and intermittent feedings and at least every 8 hours during continuous feeding.

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TABLE 57-5

Suggested Clinical Monitoring for Adult Patients Receiving Enteral Nutrition

Parameter	During Initiation of EN Therapy	During Stable EN Therapy
Vital signs	Every 4–6 hours	As needed with suspected change (ie, fever)
Weight	Daily	1–3 times per week
Total intake/output[a]	Daily	Daily monitoring of EN intake should continue. Other intake/output volumes or frequencies should be monitored as needed and with suspected changes (eg, vomiting, increased stool output, decreased urine output)
EAD		
Site (ie, tube entrance and surrounding area)	Daily	Daily
Position (ie, specific location within GI tract)	Prior to EN initiation, then ongoing	Ongoing
GI Tolerance		
Stool frequency/volume	Daily	Refer to intake/output monitoring
Abdominal assessment	Daily	Daily
Nausea or vomiting	Daily	Daily
Laboratory Data		
Electrolytes (sodium, potassium, magnesium, phosphorus, calcium), blood urea nitrogen, serum creatinine, glucose	Daily until stable, then 2–3 times/week	Every 1–3 months and as needed for suspected changes
Liver function tests	Weekly	Every 1–3 months
Micronutrients (vitamins, trace elements)	If deficiency/toxicity suspected	If deficiency/toxicity suspected

GI, gastrointestinal; EAD, enteral access device; EN, enteral nutrition.

[a]Intake may include oral/enteral nutrition intake (including water flushes), medications of all routes (including IV fluids). Output may include urine, stool (including ostomy and fistula output), drains, and wounds.

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Medication Delivery via Feeding Tube

- Administering medications via tube feeding is a common practice. Prepare solid dosage forms that are appropriate to crush as a fine powder and mix with 15–30 mL of purified water or other appropriate solvents before administering through the tube. Use of liquid dosage preparations is preferred. Administer multiple medications separately, each followed by flushing the tube with at least 15 mL of water.
- Mixing of liquid medications with EN formulations can cause physical incompatibilities that inhibit drug absorption and clog small-bore feeding tubes. Incompatibility is more common with formulations containing intact (vs hydrolyzed) protein and medications formulated as acidic syrups. Avoid mixing of liquid medications and EN formulations.
- Significant drug–nutrient interactions result in reduced bioavailability and suboptimal pharmacologic effect (**Table 57-6**). Continuous feeding requires interruption for drug administration, and medications should be spaced between bolus feedings.

TABLE 57-6

Select Medications with Special Considerations for Administration Through Enteral Feeding Devices

Drug	Interaction	Comments
Phenytoin	Reduced bioavailability in the presence of EN Possible phenytoin binding to calcium caseinates or protein hydrolysates in EN formula	Suggest holding EN 1–2 hours before and after phenytoin administration Adjust EN delivery rate to account for time held for phenytoin administration Monitor phenytoin serum concentration and clinical response closely Consider switching to IV phenytoin or an alternative option if unable to reach therapeutic serum concentration
Fluoroquinolones Tetracyclines	Potential for reduced bioavailability because of complexation of drug with divalent and trivalent cations found in EN formulations	Consider holding EN 1 hour before and after administration Avoid jejunal administration of ciprofloxacin as this bypasses portion of small bowel where ciprofloxacin is absorbed Monitor clinical response
Warfarin	Decreased absorption of warfarin because of EN; therapeutic effect antagonized by vitamin K in EN formulations	Hold EN 1 hour before and after administration Anticipate need to adjust warfarin dose when EN is initiated or discontinued
Proton pump inhibitors (lansoprazole, pantoprazole)	Administration via feeding tube complicated by acid-labile medication within delayed-release, base-labile granules	Only granules or extemporaneously prepared liquid appropriate for enteral administration Granules become sticky when moistened with water and may occlude small-bore tubes Granules should be mixed with acidic liquid (eg, apple juice) when given via a gastric feeding tube

GI, gastrointestinal; EN, enteral nutrition.

PARENTERAL NUTRITION

- PN provides macro- and micronutrients by central or peripheral venous access to meet specific nutritional requirements.
- Consider PN when nutritional requirements cannot be met using EN.

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Components of Parenteral Nutrition

- Macronutrients (ie, water, protein, dextrose, and lipid) are used for energy (dextrose and lipid) and as structural substrates (protein and lipid).
- Protein is provided as crystalline amino acids (CAAs). When oxidized, 1 g of protein yields 4 calories (~17 J). Including the caloric contribution from protein in calorie calculations is controversial; therefore, PN calories can be calculated as either total or nonprotein calories.
- Standard CAA products contain a balanced profile of essential, semi-essential, and nonessential L-amino acids and are designed for patients with "normal" organ function and nutritional requirements. These products differ in protein concentration, total nitrogen, and electrolyte content but have similar effects on protein markers.
- Carbohydrates are the primary energy source in PN solutions, usually as dextrose monohydrate, available in concentrations ranging from 5% to 70%. When oxidized, 1 g of hydrated dextrose provides 3.4 kcal (14.2 kJ).
- Commercially available lipid injectable emulsions (ILE) provide calories and essential fatty acids. These products differ in triglyceride source, fatty acid content, and essential fatty acid concentration. When oxidized, 1 g of fat yields 9 kcal (38 kJ). Caloric content of ILE is 1.1 kcal/mL (4.6 kJ/mL) for the 10%, 2 kcal/mL (8.4 kJ/mL) for the 20%, and 3 kcal/mL (12.6 kJ/mL) for the 30% emulsions due to the caloric contribution from egg phospholipid and glycerol.
- Prevent essential fatty acid deficiency with soybean oil ILE, 0.5–1 g/kg/day for neonates and infants and 100 g/wk for adults.
- ILE 10% and 20% products can be administered by a central or peripheral vein, added directly to PN solution as a total nutrient admixture (TNA) or three-in-one system (lipids, protein, glucose, and additives), or co-infused with a CAA and dextrose solution, commonly referred to as a two-in-one solution. ILE 30% is approved only for TNA preparation.
- Micronutrients (ie, vitamins, trace elements, and electrolytes) support metabolic activities for cellular homeostasis such as enzyme reactions, fluid balance, and regulation of electrophysiologic processes.
- Multivitamin products contain 13 essential vitamins, including vitamin K, to comply with guidelines for adults, children, and infants.
- Requirements for trace elements depend on the patient's age and clinical condition. Copper, manganese, selenium, and zinc are considered essential and available as single- or multiple-entity products for addition to adult, neonate, and pediatric PN solutions.
- Sodium, potassium, calcium, magnesium, phosphorus, chloride, and acetate are necessary components of PN for maintenance of numerous cellular functions. Electrolyte requirements depend on the patient's age, disease state, organ function, previous and current medication therapy, nutrition status, and extrarenal losses.

Specifics of Parenteral Nutrition

- The patient's clinical condition determines whether PN is administered through a peripheral or central vein.
- Peripheral parenteral nutrition (PPN) candidates do not have large nutritional requirements, are not fluid restricted, and are expected to regain GI tract function within 10–14 days. Solutions for PPN have lower final concentrations of amino acid (3%–5%), dextrose (5%–10%), and micronutrients as compared with central parenteral nutrition (CPN). Primary advantages of PPN include a lower risk of infectious and technical complications.
- CPN is useful in patients who require PN for more than 7–14 days and have large nutrient requirements, poor peripheral venous access, or fluctuating fluid requirements.
- CPN solutions are highly concentrated hypertonic solutions that must be administered through a large central vein. The choice of venous access site depends on factors, including patient age and anatomy. Peripherally inserted central catheters are often used for both short- and long-term central venous access in acute or home care settings.

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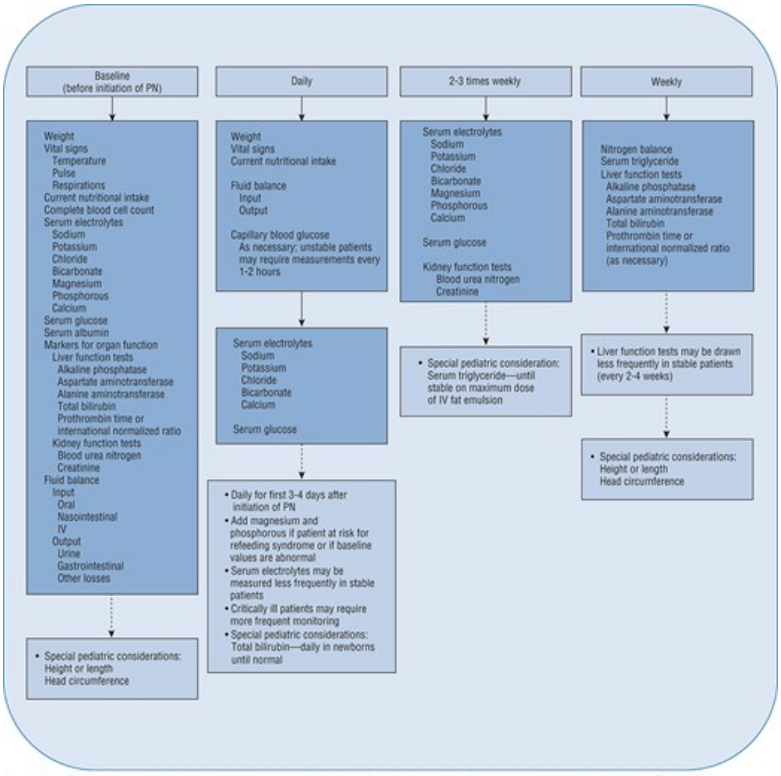
- Disadvantages of CPN include risks associated with catheter insertion, use, and care. Central venous access has a greater potential for infection.
- Standardized PN order forms for adults are popular because they help educate practitioners and foster cost-efficient nutrition support by minimizing errors in ordering, compounding, and administering.
- Pediatric PN regimens typically require an individualized approach because practice guidelines often recommend nutrient intake based on weight. Labeling should reflect the “amount per kilogram per day.”

EVALUATION OF THERAPEUTIC OUTCOMES

- Assess EN outcomes by monitoring objective measures of body composition, protein and energy balance, and subjective outcome for physiologic muscle function and wound healing.
- Measures of disease-related morbidity include length of hospital stay, infectious complications, and patient’s sense of well-being. Ultimately, the successful use of EN avoids the need for PN.
- Assess PN outcomes through routine assessment of the clinical condition of the patient, with a focus on the nutritional and metabolic effects of the PN regimen.
- Biochemical and clinical parameters should be monitored routinely in patients receiving PN (**Fig. 57-1**).

FIGURE 57-1

Monitoring strategy for patients receiving parenteral nutrition (PN).



Source: Terry L. Schwinghammer, Joseph T. DiPiro, Vicki L. Ellingrod, Lisa M. Holle, Cecily V. DiPiro: *DiPiro's Pharmacotherapy Handbook, 13th Edition*
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See Chapter 10, Assessment of Nutrition Status and Nutrition Requirements, authored by Angela L. Bingham and Katherine H. Chessman; Chapter 11, Parenteral Nutrition, authored by Todd W. Mattox and Catherine M. Crill; and Chapter 12 Enteral Nutrition, authored by Diana W. Mulherin and Sarah V. Cogle, for a more detailed discussion of this topic.

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